Inferred seismic performance and recovery of the Christchurch water supply network following the 22 February 2011 M_w 6.2 Christchurch earthquake

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Introduction

This poster presents the inferred initial performance and recovery of the water supply network of Christchurch following the 22 February 2011 Mw 6.2 earthquake. Results are presented in a geospatial and temporal fashion. This work strengthens the current understanding of the restoration of such a system after a disaster and quantifies the losses caused by this earthquake in respect with the Christchurch community. Figure 1 presents the topology of the water supply network as well as the spatial distribution of the buildings and their use.

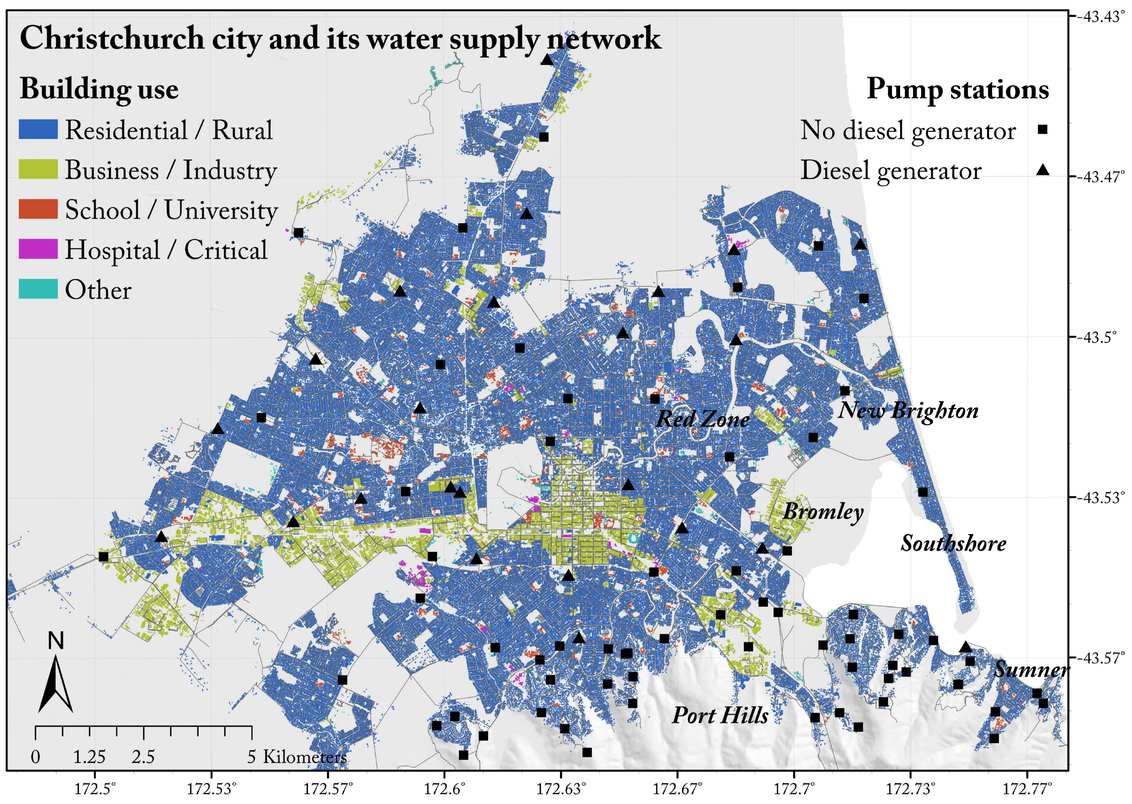

Figure 1: Map of the Christchurch urban area showing both the buildings and their usage as well as the water supply network topology.

Immediate post-event network performance

Assumptions:

The initial performance of the water supply network is inferred from the reported pipe failures and the pump station operational status. Pump stations equipped with diesel power generator within the power outage areas are assumed to be operational after one day. The water flow is not modelled, pump stations are assumed infinite water sources, the buildings are assumed to be connected to the closest submain pipe and private connections are not taken into account.

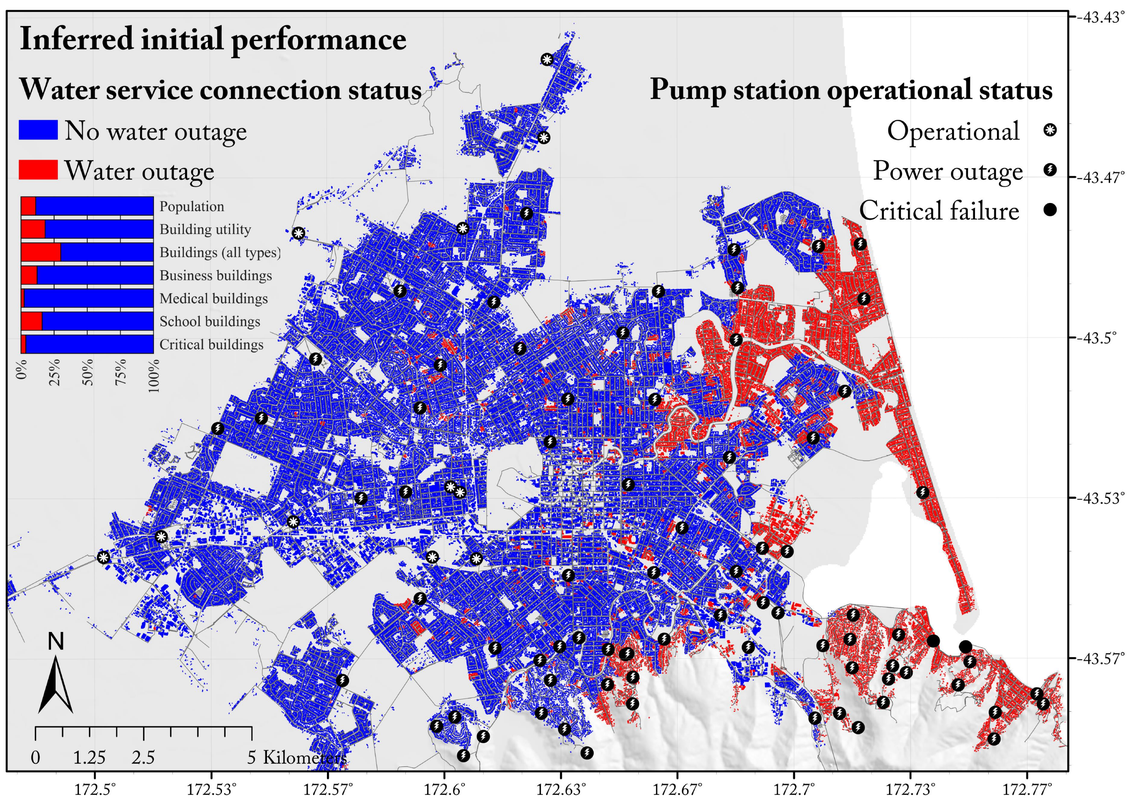

Figure 2: Map of the inferred initial performance of the water supply network considering power outage and pipe damage on the day of the 22 February 2011 Mw 6.2 Christchurch earthquake.

Geospatial results:

Figure 2 presents the map of the inferred initial performance. On the day of the event, Giovinazzi et al. (2011) reported that 50% of the city was deprived from water. The presented model largely underestimates the disruption on the day of the event. However, as most of the pump stations have been brought back to service on the first day of the recovery, the inferred initial performance is considered to be a reliable estimation of the water outage. Both regions that are topographically isolated like New Brighton, Southshore or Sumner and that experienced high damage level like the Red Zone are the most impacted.

Inferred recovery

Assumptions:

The recovery was inferred from successive connectivity analyses that were carried out on the updated network damage and pump station operational status for each day of the recovery.

Geospatial results:

It can be observed in Figure 3 that the most topographically isolated areas of the city tend to recover water access later than their more central counterparts. It must also be noted that the Red Zone's restoration also required a significant amount of time due to the very high damage extent.

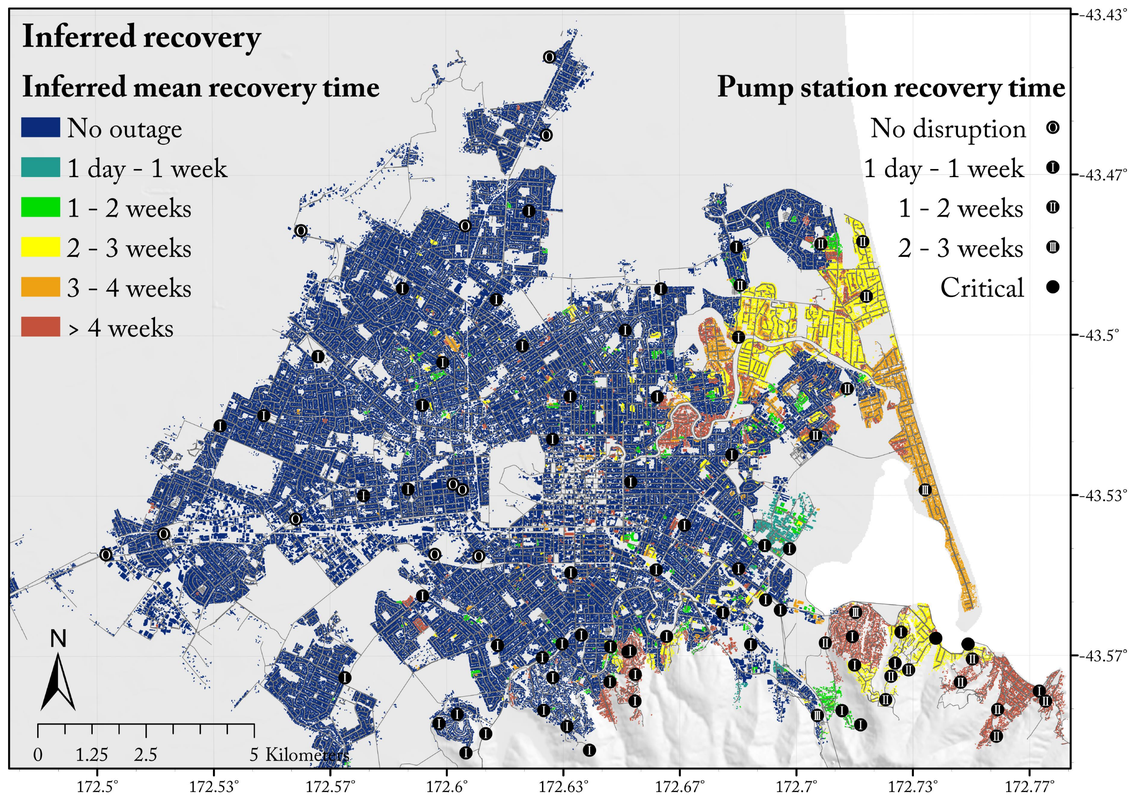

Figure 3: Map of the inferred duration of the water outage following the 22 February 2011 Mw 6.2 Christchurch earthquake.

Temporal results:

Figure 4 shows the recovery curves for several city-scale metrics, the interpolated recovery curve from water outage extent reported by Giovinazzi et al. (2011) on the day, after a week and after a month of the event as well as the estimated date of repair completion by Eidinger and Tang (2012) and O'Rourke et al. (2014). The two given dates of repair completion tend to corroborate the inferred recovery results. The inferred recovery curves also align well with the interpolated results given by previous research after most of the pump have been brought back to service.

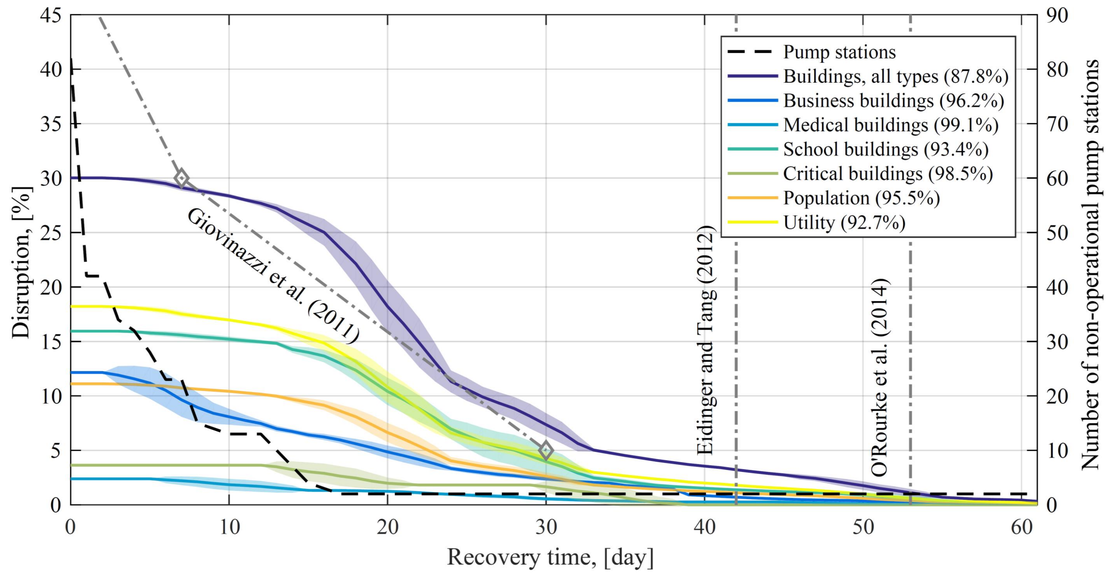

Figure 4: Water access recovery curves and resilience of the selected metrics following the 22 February 2011 Mw 6.2 Christchurch earthquake ; pump station restoration time ; estimated completion of the repair work by Eidinger and Tang (2012) and O'Rourke et al. (2014) ; and interpolation between the levels of disruption (indicated by diamonds) reported by Giovinazzi et al. (2011).

Conclusion

Absent from previous studies, the presented geospatial and temporal insights allow a comprehensive understanding of the historical recovery process that enables its retrospective analysis. Main conclusions are:

- This work allows a quantifiable assessment of the recovery, which should help both local authorities and private owners to mitigate losses and optimize recovery for potential future events.
- It underlines the importance of power availability to operate a water supply network.
- Finally, it also shows that pipe damage remains critical for the restoration of the water services. Hence, this work has subsequently served as a basis to develop an optimization method to minimize water outage impacts.